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Social inequality and infant health in the UK: systematic review and meta-analyses

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ABSTRACT

Objectives: To determine the association between area and individual measures of social disadvantage and infant health in the UK.

Design: Systematic review and meta-analyses.

Data sources: 26 databases and websites, reference lists, experts in the field and hand-searching.

Study selection: 36 prospective and retrospective observational studies with socioeconomic data and health outcomes for infants in the UK, published from 1994 to May 2011.

Data extraction and synthesis: 2 independent reviewers assessed the methodological quality of the studies and abstracted data. Where possible, study outcomes were reported as ORs for the highest versus the lowest deprivation quintile.

Results: In relation to the highest versus lowest area deprivation quintiles, the odds of adverse birth outcomes were 1.81 (95% CI 1.71 to 1.92) for low birth weight, 1.67 (95% CI 1.42 to 1.96) for premature birth and 1.54 (95% CI 1.39 to 1.72) for stillbirth. For infant mortality rates, the ORs were 1.72 (95% CI 1.37 to 2.15) overall, 1.61 (95% CI 1.08 to 2.39) for neonatal and 2.31 (95% CI 2.03 to 2.64) for post-neonatal mortality. For lowest versus highest social class, the odds were 1.79 (95% CI 1.43 to 2.24) for low birth weight, 1.52 (95% CI 1.44 to 1.61) for overall infant mortality, 1.42 (95% CI 1.33 to1.51) for neonatal and 1.69 (95% CI 1.53 to 1.87) for post-neonatal mortality. There are similar patterns for other infant health outcomes with the possible exception of failure to thrive, where there is no clear association.

Conclusions: This review quantifies the influence of social disadvantage on infant outcomes in the UK. The magnitude of effect is similar across a range of area and individual deprivation measures and birth and mortality outcomes. Further research should explore the factors that are more proximal to mothers and infants, to help throw light on the most appropriate times to provide support and the form(s) that this support should take.

ARTICLE SUMMARY

Article focus

- To determine the association between area and individual measures of social disadvantage and infant health in the UK.

Key messages

- It is possible to be reasonably confident of the magnitude of effect of social disadvantage on health outcomes for UK infants, in particular the effects of area or individual deprivation on birth outcomes and infant mortality.
- The magnitude of effect, of a range of measures of social disadvantage on infant health outcomes, is broadly similar and has remained so over the past 30 years.
- Future research should concentrate on the more proximal determinants of infant health outcomes (such as individual maternal and infant factors) and the impact of any interventions employed to mitigate these determinants.

Strengths and limitations of this study

- A rigorous systematic review and accompanying meta-analyses provide confidence in the findings.
- Specific relevance to the UK.
- A risk of publication bias (missing studies) cannot be ruled out though, given the large size of many included studies, the likely effect is minimal.
- The review concentrates on health outcomes only.

INTRODUCTION

Socioeconomic status, as indicated by level of income, education, wealth, occupation and access to resources, is well established as associated with an individual's health and well-being. Furthermore, the correlation is evident throughout the life course. Such social variables are key elements of the aetiology of ill health and disease.[1–3] The same social factors also determine the health and life chances of the unborn and newborn child and impact on early child development. These interactions have been theorised in the social–ecological model of health, which acknowledges the

cumulative impact of individual, familial, community and societal forces on people's health.[4 5]

The UK government and devolved administrations are committed to tackling the social, economic and environmental factors that influence health through evidence-based approaches to the underlying social determinants of ill health and to interventions to address these inequalities.[6–9] This approach is in line with the conclusions of WHO sponsored Commission on the Social Determinants of Health.[3]

Birth and early development play a vital role in creating and maintaining socioeconomic health inequalities through adulthood.[6 10] From a pathway approach, early development from conception to 5 years of age is widely accepted as establishing the foundation for learning, behaviour and health throughout the life cycle.[11] WHO Commission on the Social Determinants of Health in particular stressed the critical role of child health in addressing inequities in health. Investments in child health and development are seen as forces to equalise health status through the life course.[3] These points were reiterated in the recent Marmot Review, which particularly stressed the importance of giving every child the best possible start in life.[6]

There is an implicit recognition of the importance of social determinants to the well-being of children in national policy. For example, a stated aim of 'Healthy Lives, Brighter Futures' is to get the right services, advice and support to all parents with more intensive support for the most vulnerable.[12]

The UK performs very poorly in comparison with similar countries on mortality among the under 5s.[13] A recent index of child well-being in the European Union[14] suggested that the UK ranked 24/29 for both child health from birth and overall child well-being. Furthermore, the UK had a stillbirth rate of 3.5 per 1000 births in 2009. Within high-income nations, only France and Austria had higher levels.[15] Such poor outcomes in comparison to our nearest neighbours suggest that significant action is required to improve health and well-being in childhood.

The objectives of this review were to assess the current evidence for the effects of social disadvantage on birth and infant outcomes for children born in the UK to provide a firm basis for practitioners and policy makers on which to measure the effect of interventions to address these inequalities. This systematic review builds on a previous review of prospective studies carried out for the Welsh government to examine the social determinants of child health in the UK and to develop social indicators from these determinants.[16]

This analysis provides a current summary of relevant and well-conducted epidemiological research into the links between social determinants and infant health in the UK.

METHODS

Inclusion/exclusion criteria

Research studies were sought that reported socioeconomic data and health outcomes for infants (0–12 months) and were carried out in the UK and published between January 1994 and May 2011. The most recent update search was completed on 19 May 2011. There were no language exclusions. A 'best evidence' approach was adopted by using data from longitudinal and record linkage studies. Prospective cohort, case–control and retrospective cohort studies with a sample size of 200 or more were included, as well as record linkage analyses of routinely collected data. Case studies and cross-sectional surveys (with data from a single time point) were excluded.

The outcome criteria for the studies were preterm birth, birth weight, mortality, diagnosed illness, attendance at primary or secondary care in relation to ill health, infection, injury or disability, growth and development. The social determinants explored were specific area-based and individual measures of social disadvantage which included area deprivation scores[17–20] and individual measures of deprivation (occupational social class, household income/poverty, parental educational status). Lone parenthood was also included as a social determinant, albeit not a direct measure of social disadvantage.

To ensure that the review focused on specific infant health outcomes for the general current population, papers on the following topics were excluded: congenital malformations, in-care or adopted infants, infants with pre-existing medical conditions, specific subgroups of mothers (eg, previous major pregnancy complication) and data from pre-1970. Access to treatment or screening services, immunisation uptake, child abuse or domestic violence studies were excluded unless reported with a social determinant and child health outcome.

Search sources and search strategy

The following databases, websites and other sources were searched: ASSIA (Cambridge Scientific Abstracts); British Nursing Index (OVID); ChildData; CINAHL (Ebsco); Community Wise; Conference Proceedings Citation Index—Science and Social Science & Humanities (Web of Science); Embase (OVID); EPPI Centre DoPHER; HMIC (OVID); Joseph Rowntree Foundation; Local Government Data Unit Wales; Medline (OVID); Medline in Process (OVID); NHS Plans and National Service Frameworks for Wales and England in relation to children; National Institute for Health and Clinical Excellence (NICE); Office for National Statistics; PsycINFO (OVID); ReFER (archive up to September 2007); Science Citation Index (Web of Science); Open SIGLE (replaced by OpenGrey), Social Care Online; Social Science Citation Index (Web of Science); Social Services Abstracts; Sociological Abstracts (Cambridge Scientific Abstracts); WHO Health Evidence Network.

The search terms were developed and tested by qualified librarians (HK and ALW) in one database, Medline, to a high recall of relevant studies (sensitive) without too many irrelevant studies (specific).

The following search terms were used in Medline (where * is the truncation symbol; ab=abstract;

cp=country of publication, pt=publication type; ti=title; /=subject heading):

Infant health

Exp infants/OR (Babies or baby or birth* or infant* or neonatal or newborn or perinatal or postnatal or neonatal or perinatal).ab,ti.

AND

Social determinants

Exp socioeconomic factors/OR exp social class/OR (benefit recipient* or deprivation or economic inactivity or educational achievement or educational attainment or employment status or financial hardship or home own* or house own* or housing tenure or inequalit* or inequit* or job opportunit* or lone parent or low income or low pay or marital separation) OR (neglect or overcrowd* or poor environment or poor housing or poverty or property own* or prosperity or single parent* or social adversity or social capital or social class or social disadvantage or social disparit* or social exclusion or social inclusion or social gradient or social housing or social integration or social interaction) OR (social isolation or social mobility or social network* or social position or social relationship* or social security or social status or social stigma or social trend* or social welfare or sociodemographic or socioeconomic or socio-demographic or socio-economic or sole parent or standard of living or unemploy*).ab,ti.

AND

Study designs

exp Meta-Analysis/ OR review.pt OR (census* or cohort* or survey* or evaluat* or longitudinal* or questionnaire* or meta-analys* or metaanaly* or meta analys* or registry or registries or systematic* review* or systematic overview).ti,ab.

AND

Exp Great Britain/ OR (UK OR United Kingdom OR England OR Wales OR Scotland OR Britain OR British OR English OR Welsh OR Ireland OR Irish OR Scottish).ti,ab,cp.

Searches were adapted to other databases to replicate, as closely as possible, the Medline search. In addition, and to minimise the potential for publication bias, a range of supplementary ('snowballing') techniques was used to increase the sensitivity of the search and to ensure coverage of grey literature and unpublished studies. These included reference list follow-up, citation tracking of relevant studies (to find newer studies), contact with subject experts and organisations, and table of contents scanning for the journals that appeared most frequently in the list of relevant studies: *Journal of Epidemiology and Community Health*, *Archives of Disease in Childhood* (including the *Fetal and Neonatal edition*) and *British Medical Journal*. Finally, all systematic reviews on relevant topics were unpicked for primary studies meeting inclusion/exclusion criteria. This included the publication on which this review builds[16] and a more recent systematic search carried out by members of the same team for the Welsh government to support the development of a Child Health Monitor.[21]

Duplicate references were excluded. All titles and, where necessary, abstracts were then screened to eliminate duplicates and obviously irrelevant citations. The full text of all potentially relevant papers was retrieved and screened independently for eligibility by two reviewers using a standardised eligibility form, with adjudication from a third reviewer in cases of disagreement (HK, HEM, MAS and ALW).

Following screening of 5173 citations found in the literature search, 88 papers potentially met the inclusion criteria and were examined in full text. Thirty-six studies met all inclusion and critical appraisal criteria and were included in the final review. Details are given in the flow diagram of figure 1

Classification of social determinants

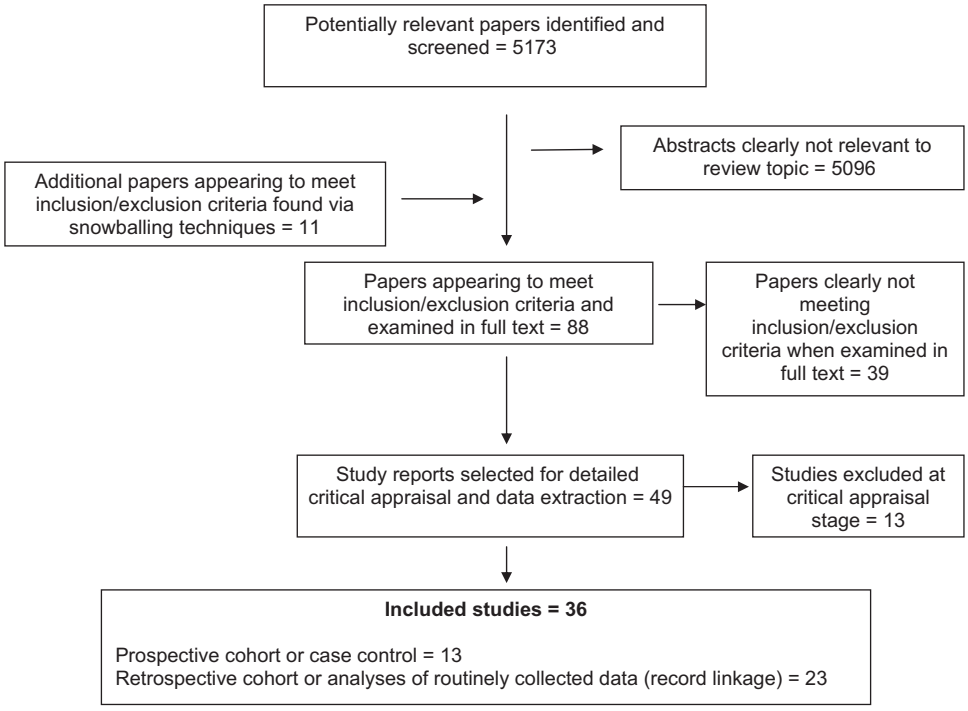
Many studies, particularly those using routine data, use area-based deprivation data such as the Townsend[20] and Carstairs[17] scores, the UK Indices of Multiple Deprivation (IMD)[19] and the Jarman Index.[18] These are derived from routine data sources, including census data. Most researchers divide geographical units into classes, such as quintiles, based on these deprivation scores. Different geographical areas are used, ranging from enumeration districts, with a population of around 500, to Electoral Wards, with about 3000 people. Many recent studies use the 2001 UK Census geographical unit of Lower Super Output Area containing, on average, a population of 1500.

Some studies used social class, usually based on the Registrar General's classification, instead of an area measure. This has the advantage of being an individual measure and is recorded by the Office for National Statistics on a randomly selected 10% of births. Most studies which used this measure compared class I, consisting of professionals, with class V, made up of unskilled manual workers.

Critical appraisal and data extraction

Following pre-tests to confirm inter-rater reliability and iron out any queries, data were extracted independently by two reviewers (shared by FDD, HEM, MAS, ALW). Each study was assessed for quality against a critical appraisal checklist based on the Newcastle–Ottawa Quality Assessment Scale (NOS).[22] Any disagreements were resolved by a third reviewer. There is, as yet, no internationally established quality assessment tool for observational epidemiological studies,[23] and the NOS has not been validated.[24] Thus, the tool was used to help identify potential methodological weaknesses rather than to provide a definitive quality score for each study. Methodological quality indicators (study design, data sources, response rate and any adjustments to control for baseline variables) were summarised in the Evidence Table (online appendix 1).

Figure 1 Flow diagram.



A paper was excluded if it did not provide usable data to allow a quantitative comparison of the risk for a health outcome in relation to a measure of individual or area social inequality with an indication of statistical significance (CI or p value). If a research publication reported a non-significant result without supporting data, but the statistical rigour suggested that this was a reliable result, a non-significant result was recorded. In the latter case, it was clearly not possible to include these papers in any meta-analysis.

The key components of the data extraction and critical appraisal outcomes are presented in the Evidence Table (online appendix 1). Details of the eligibility, critical appraisal and data extraction methods are available from the authors.

Study outcomes were analysed by a statistician (FDD) and reported as described by the authors of each paper. Where possible, outcomes were reported as an 'effect size' observed with subjects from highest versus lowest deprivation exposures in the Evidence Table (online appendix 1 and 2) to allow comparability between studies. In some cases, the authors did not report the data in the most suitable way, but it was possible to calculate effect sizes and CIs from the data shown. Where possible, an OR comparing the highest and lowest deprivation levels was calculated, as this was the most commonly reported measure. As most outcomes measured were relatively rare, differences between relative risks and ORs will be modest. Some studies adjusted the ORs to allow for confounders, and where possible, the most adjusted data have been reported.

Meta-analyses were carried out, where possible, when a group of papers were sufficiently homogeneous in respect of both outcome and deprivation measures. Because adjustments varied between studies, these analyses were carried out on unadjusted results. Random effects models were used to allow for heterogeneity. The number of studies on any one outcome was too small for funnel plots to be of any value so the risk of publication bias cannot be excluded. However, given the huge size of many of the studies included, CIs are quite narrow and missing small studies would likely have little effect.

RESULTS

Thirty-six studies met the inclusion criteria, of which 13 were prospective cohort (longitudinal) or case–control studies and 23 were based on data collected retrospectively from medical records or routinely collected data (eg, record linkage between a health outcomes register and census data). Findings are summarised in table 1 and detailed in the text. Summary data from each included study are given in online appendix 1.

Birth weight, prematurity and cerebral palsy

Birth weight, prematurity and cerebral palsy are very closely linked outcomes,[41] which are considered together.

Low birth weight

Nine studies (Paranjothy, 2010, unpublished)[25–31 42] considered the outcome of low birth weight or very low birth weight, defined as <2500 g or <1500 g, respectively; none considered birth weight as a continuous outcome.

These are all based on large routinely collected data sets but they differ in the measures of deprivation used and in the adjustments made in analyses. In general, the studies did not control for gestational age to distinguish premature from small-for-dates babies.

Table 1 Social determinants related to specific infant health outcomes: summary results from meta-analyses

Health outcome	Social determinant	Prospective and case–control studies	Retrospective studies	Summary magnitude of effect*, OR: most vs least deprived quintiles
Birth				
Very low birth weight	Area deprivation		Bundred *et al*[25] Dibben *et al*[26] Paranjothy (2010, unpublished) Spencer *et al*[27]	1.61 (1.31 to 1.97)
Low birth weight	Area deprivation	Collingwood Bakeo and Clarke[28]	Bundred *et al*[25] Dibben *et al*[26] Gray *et al*[29] Paranjothy (2010, unpublished) Pattenden *et al*[30] Spencer *et al*[27]	1.81 (1.71 to 1.92)
	Lower social class		Fairley and Leyland[31] Maher and Macfarlane[32] Pattenden *et al*[30] Spencer *et al*[27]	1.79 (1.43 to 2.24)
Preterm birth (preterm/ very preterm combined)	Area deprivation	Smith *et al*[33] Yuan *et al*[35]	Gray *et al*[34] Paranjothy (2010, unpublished)	1.67 (1.42 to 1.96)
Stillbirth	Area deprivation		Gray *et al*[29] Paranjothy (2010, unpublished)	1.54 (1.39 to 1.72)
Infant health				
Infant mortality overall	Area deprivation		Dummer and Parker[36] Gray *et al*[29] Oakley *et al*[37]	1.72 (1.37 to 2.15)
	Lower social class		Dummer and Parker[36] Whitehead and Drever[38] Oakley *et al*[37]	1.52 (1.44 to 1.61)
Neonatal mortality	Area deprivation		Dummer and Parker[36] Gray *et al*[29] Smith *et al*[39]	1.61 (1.08 to 2.39)
	Lower social class		Dummer and Parker[36] Oakley *et al*[37] Whitehead and Drever[38]	1.42 (1.33 to 1.51)
Postneonatal mortality	Area deprivation		Dummer and Parker[36] Gray *et al*[29] Oakley *et al*[37]	2.31 (2.03 to 2.64)
	Lower social class		Dummer and Parker[36] Whitehead and Drever [38] Oakley *et al*[37] Petrou *et al*[40]	1.69 (1.53 to 1.87)

*To avoid double counting, meta-analyses were carried out using only those studies without overlapping data.

Different studies used different time periods, and it is possible that the effect of deprivation has changed over recent decades. However, two studies which subdivided the data into different decades[28 31] suggest that the effects have not changed markedly since 1980. Some studies adjusted for confounders, typically maternal age, gender of child and whether the registration was joint or single parent (mother) only. ORs, adjusted for these potential confounders, were generally considerably closer to the null value of 1 than unadjusted ones, reflecting the importance of these factors.

In seven studies that compared area measures (Paranjothy, 2010, unpublished),[25–30] the unadjusted ORs, comparing the most and least deprived, varied from 1.67 to 2.01. Combining the estimates in a random effects meta-analysis, the resulting OR was 1.81 (95% CI 1.71 to 1.92) (figure 2). The study by Wright *et al*[42] was not included in the meta-analysis because the definitions of area deprivation are unclear and it is not possible to calculate ORs with any degree of certainty.

One further study[43] looked at the specific issue of small for gestational age babies in the West Midlands (birth weight <10th customised centile). For UK IMD quintile 5 versus IMD 1-3 (personal communication from author), the RR of small for gestational age was 1.2 (95% CI 1.1 to 1.3). Since both outcome and comparator measures vary from the other studies, this result was not included in the meta-analysis.

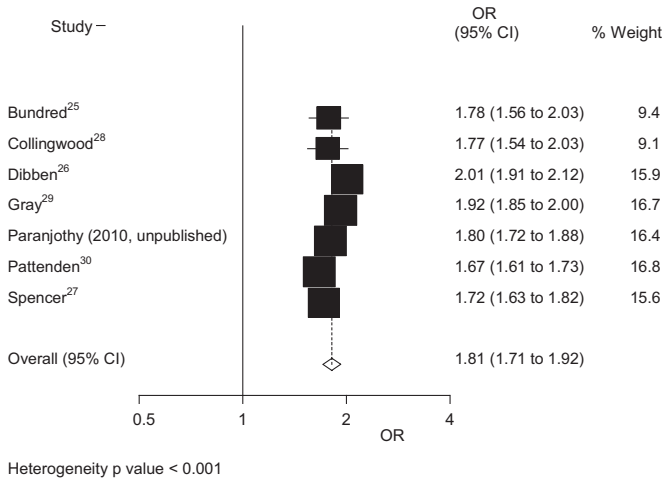


Figure 2 Low birth weight versus area deprivation.

Five studies[26 27 30–32] measured deprivation at an individual level using the Registrar General's social class categories. All but Maher and Macfarlane[32] compared social class V with social class I; Maher and Macfarlane compared manual and non-manual workers, and this is probably a less extreme comparison, leading to a smaller OR. For social class, as opposed to area deprivation, Dibben *et al*[26] only reported a heavily adjusted OR of 1.20 and thus was not included in the meta-analysis. The unadjusted estimates of the OR varied from 1.45 to 2.17. Excluding Dibben *et al*,[26] a random effects model pooling these gave an overall estimate of 1.79 (95% CI 1.43 to 2.24), very similar to the estimate for the area-based measures (figure 3).

Several authors, including Fairley and Leyland[31] and Paranjothy (2010, unpublished), noted that the effects of deprivation appeared to be greater in older mothers. This may merit further investigation.

Four of the studies (Paranjothy, 2010, unpublished)[25–27] also examined the incidence of very low birth weight against area-based measures. There was greater heterogeneity in this case, with estimates of the OR varying between 1.29 and 2.54. The meta-analysis gave a combined OR of 1.61 (95% CI 1.31 to 1.97) (figure 4). Again there was evidence from Paranjothy that this OR increased with maternal age.

In all the above cases, there was considerable heterogeneity; the reasons for this are not clear. All studies used large samples of routine data and, within each analysis, used broadly comparable measures of deprivation.

Overall, it is clear that deprivation is strongly associated with low and very low birth weight. The effect may vary with maternal factors such as age, and this needs further investigation.

Two studies[26 30] found a statistically significant relationship between lone parenthood and low birth weight with estimated ORs of 1.16 (95% CI 1.09 to 1.25) and 1.46 (95% CI 1.41 to 1.52), respectively, though Pattenden *et al*[30] used single registration, not identical to lone parenthood, and the result of Dibben *et al*[26] was heavily adjusted.

Prematurity

Six papers considered preterm birth as an outcome (Paranjothy, 2010, unpublished).[33–35 42 44] Smith *et al*[44] used 549 618 births from 1994 to 2003 from the Trent region and defined very preterm birth as 22–32 weeks and extremely preterm birth as 22–28 weeks. Combining their deciles into quintiles, the unadjusted OR for very preterm, comparing the most and least deprived quintiles, was 1.72 (95% CI 1.59 to 1.86). For extremely preterm birth, this was 1.74 (95% CI 1.54 to 1.98). Their analysis included all babies alive at the start of labour. A later paper[33] reported on a different but overlapping 10-year period from the same region. The ORs were a little higher. Paranjothy (2010, unpublished) included stillbirths in an analysis of 408 445 births in Wales between 1994 and 2005 and found an OR of 1.44 (95% CI 1.32 to 1.56) for very preterm births, comparing the most and least deprived quintiles based on the Townsend score, and the corresponding OR for extremely preterm births was 1.38 (95% CI 1.20 to 1.57). Excluding stillbirths had little effect. Gray *et al*[34]

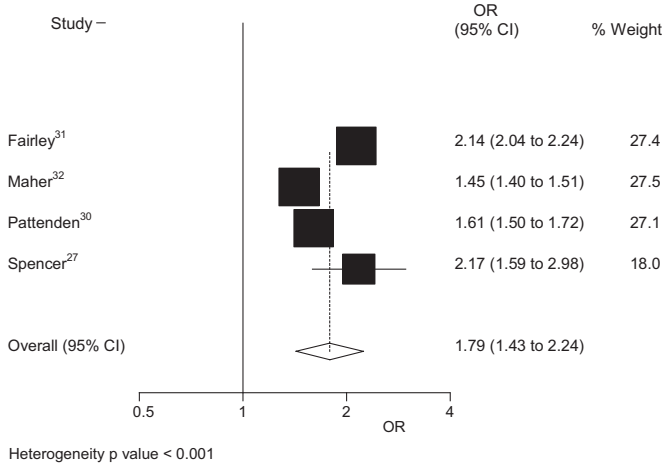


Figure 3 Low birth weight versus social class.

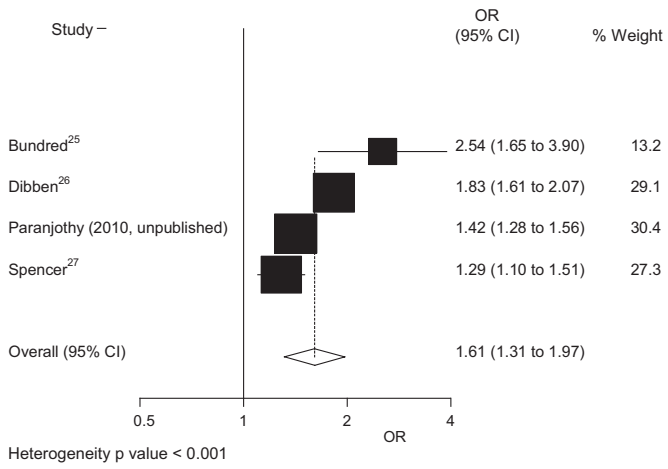


Figure 4 Very low birth weight versus area deprivation.

considered all preterm births, defined as being <37 weeks, the OR was 1.47 (95% CI 1.42 to 1.52). Since the majority of preterm births are after 32 weeks, this broadly similar result suggests that the association with deprivation is similar at different stages of prematurity. The study by Wright *et al*[42] in Newcastle found that the RR for most deprived versus most affluent areas was 2.95 (95% CI 1.61 to 5.38). The definitions of area deprivation are unclear and thus it is not possible to calculate ORs with any degree of certainty. Thus, this paper was not included in the meta-analysis.

Yuan *et al*[35] used a case–control study to compare the prevalence of social problems in those whose pregnancy ended at term (≥37 weeks) compared with preterm (<35 weeks), the OR was 2.42 (95% CI 1.60 to 3.66). The definition of social problems is likely to identify more seriously deprived mothers than those studies using social class, and this may account for the more extreme result.

The varying definitions of prematurity in these studies mean it is thus arguable that a meta-analysis is not appropriate in this case. However, to give an indication of effect sizes, combining four studies, with useable data and no overlaps (Paranjothy, 2010, unpublished),[33–35] all of which related to area deprivation, gave an OR of 1.67 (95% CI 1.42 to 1.96) (figure 5). The conclusions on prematurity were therefore similar to those for low birth weight, which is strongly related to prematurity. Stillbirth is discussed further under infant mortality.

Cerebral palsy

Two studies considered the relationship between cerebral palsy and area deprivation.[45 46] Sundrum *et al*[45] used births in West Sussex and found an OR of 1.65 (95% CI 1.14 to 2.39) comparing extreme quintiles based on the Townsend score for enumeration districts. Adjusting for birth weight and gestation age gave a revised estimate of 1.55 (95% CI 1.06 to 2.25). Dolk *et al*[46] examined over 1.5 million births in five regions of the UK. Cases of cerebral palsy were divided into those acquired postnatally and those present at birth. For the former, the OR, comparing extreme quintiles based on the Carstairs score at electoral ward level, was 1.86 (95% CI 1.19 to 2.88). For non-acquired cases, the association with deprivation had the corresponding OR of 1.16 (95% CI 1.00 to 1.35). When this was adjusted for birth weight, it was reduced to 1.05 (95% CI 0.86 to 1.29), a non-significant result. This suggests that the effect of deprivation acts largely through low birth weight. There was evidence of considerable heterogeneity between regions, and this requires further investigation to seek possible explanations.

Infant mortality

Infant mortality is traditionally classified by the age of the child at death. Neonatal mortality refers to deaths up to 27 days after the birth, with those up to day 6 classed as early neonatal; the remaining neonatal deaths are termed late neonatal. Those after 27 days but up to a year are called postneonatal, while infant deaths are those between birth and a year. A stillborn baby is a baby born after the 24th week of pregnancy who does not show any signs of life. Perinatal mortality combines stillbirths and early neonatal deaths. An analysis of infant mortality needs to be separated into these different time periods as any possible effects of deprivation may operate differently in the neonatal period from the postneonatal period, for example.

For stillbirths, there were four studies (Paranjothy, 2010, unpublished)[29 47 48] all of which postdate the change in definition resulting from the Still-Birth (Definition) Act of 1992; when births from 24-week gestation were included, the data by Guildea *et al*[47] were subsumed by that of Paranjothy. Published data from Guildea *et al*[47] are, however, included in the Evidence Table (online appendix 1). Gray *et al*,[29] using data from Scotland from 1994 to 2003, found an OR of 1.56 (95% CI 1.38 to 1.77) comparing extreme quintiles based on Carstairs scores calculated for postcode sectors. Paranjothy (2010, unpublished) found a very similar OR of 1.54 (95% CI 1.32 to 1.80) comparing extreme quintiles of the Townsend score calculated for lower super output areas. Combining these two studies (Paranjothy, 2010, unpublished),[29] a pooled estimate of the OR is 1.54 (95% CI 1.39 to 1.72) (figure 6).

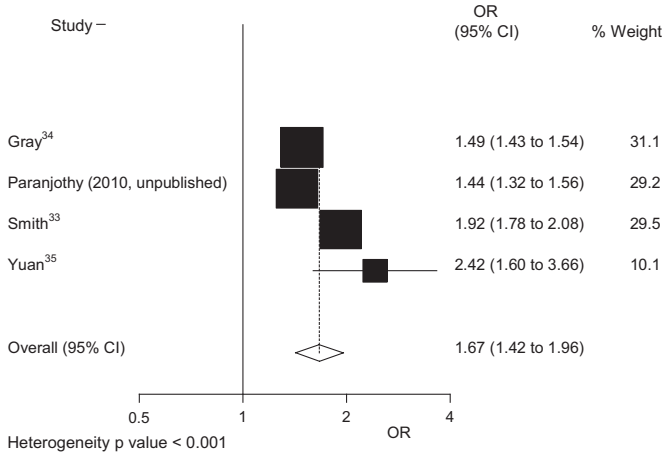


Figure 5 Preterm birth versus area deprivation.

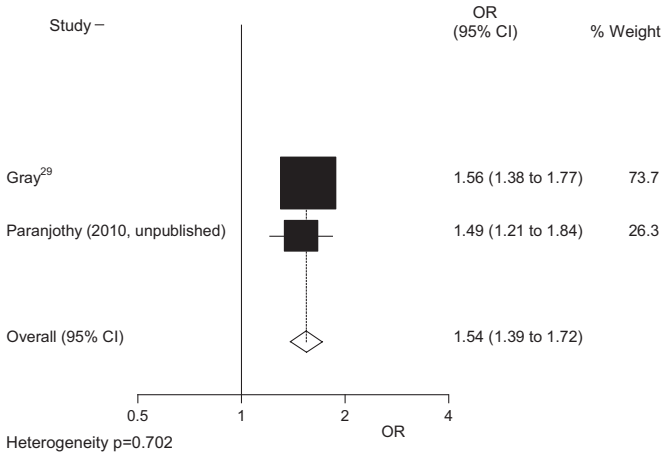


Figure 6 Stillbirth versus area deprivation.

Smeeton *et al*[48] used a case–control study in a Health Authority in London to study stillbirths, using the Jarman score to measure deprivation. The presumption is that the results were not statistically significant as no useable data were shown.

Bambang *et al*[49] was most concerned with specific causes of perinatal death in one English region; the association with deprivation varied relatively little with cause, and combining the causes gave an OR of 1.91 (95% CI 1.66 to 2.20) comparing extreme quintiles based on Townsend scores.

Four studies[36 40 47 48] examined early neonatal death as a separate outcome; all but Smeeton also considered late neonatal mortality. Two of these studies[40 47] found that the risk of late neonatal mortality was higher in more deprived areas, with very different ORs. Generally, results varied considerably and details are shown in online appendix 1. There was more evidence for an association of deprivation with late neonatal than early neonatal deaths.

Whitehead and Drever[38] gave results for perinatal mortality, which includes stillbirths and early neonatal deaths within 7 days of birth. Using data on over 14 million births from a 22-year period from England and Wales, they found an OR of 1.35 (95% CI 1.30 to 1.40).

Whitehead and Drever[38] also compared overall neonatal mortality between classes IV and V and classes I and II. The rate was significantly higher in classes IV and V, with an OR of 1.41 with approximate 95% CI 1.32 to 1.51. As about 75% of neonatal deaths are early neonatal deaths, it is likely that an association existed with early neonatal death. Gray *et al*[29] studied over 500 000 births in Scotland between 1994 and 2003; the OR for comparing quintiles based on Carstairs–Morris scores was 1.37 (95% CI 1.16 to 1.62). Oakley *et al*[37] took all 1 276 198 singleton births in England and Wales in 2005 and 2006 and found an OR of 2.00 (95% CI 1.79 to 2.24) comparing quintiles based on Carstairs scores. For a 10% sample, those who are routine or manual workers were compared with the category of Higher and Professional workers; the OR was 1.54 (95% CI 1.20 to 1.98). Smith *et al*[39] took all live births in England between 1997 and 2007, more than 6 million in total. Comparing the most extreme quintiles, based on the Index of Multiple Deprivation, the OR was 2.19 (95% CI 2.09 to 2.29). Dummer and Parker[36] found an OR of 1.28 (95% CI 0.82 to 2.01) comparing extreme deprivation quintiles in Cumbria. A meta-analysis was performed but Oakley *et al*[37] was omitted, as its study population was largely subsumed by that of Smith *et al*.[39] The pooled OR, comparing the extreme quintiles from these three studies,[29 36 39] was 1.61 (95% CI 1.08 to 2.39) (figure 7).

A meta-analysis comparing the extremes of social class from three studies looking at neonatal mortality[36–38] gave a pooled OR of 1.42 (95% CI 1.33 to 1.51) (figure 8).

In summary, there does seem to be evidence for an effect of both area deprivation and social class on neonatal mortality, although there is considerable heterogeneity between studies.

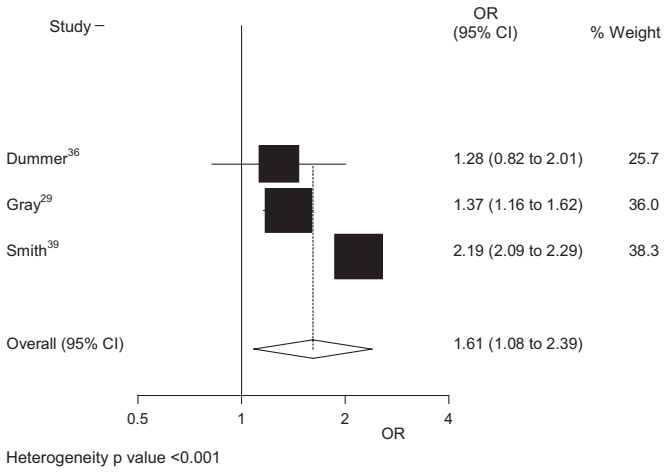


Figure 7 Neonatal mortality versus area deprivation.

Six studies[29 36–38 40 47] assessed the effect of deprivation on postneonatal mortality. All found that the unadjusted rates were significantly higher in the most deprived areas compared with the least deprived, with ORs of 2.26 (95% CI 1.29 to 3.93) in Dummer and Parker,[36] 2.20 (95% CI 1.77 to 2.72) in Guildea *et al*,[47] 2.55 (95% CI 2.01 to 3.23) in Gray *et al*[29] and 2.21 (95% CI 1.87 to 2.61) in Oakley *et al*.[37] The data from Guildea *et al*[47] were not available in a form that could be included in the meta-analysis. A pooled OR was 2.31 (95% CI 2.03 to 2.64) for the other three studies[29 36 37] (figure 9). If raw data from Paranjothy (2010, unpublished) are included, which represent (and subsume) the Guildea *et al*[47] population, the pooled OR is very similar, 2.28 (95% CI 2.04 to 2.56).

Comparing social class, Dummer and Parker[36] found an OR of 2.24 (95% CI 0.81 to 6.23) and Petrou *et al*[40] recorded 1.70 (95% CI 1.14 to 2.54) comparing classes V and I. Whitehead and Drever[38] found an OR of 1.69 (95% CI 1.52 to 1.88) for comparing classes IV and V with I and II. Oakley *et al*[37] used the newer NS_SEC

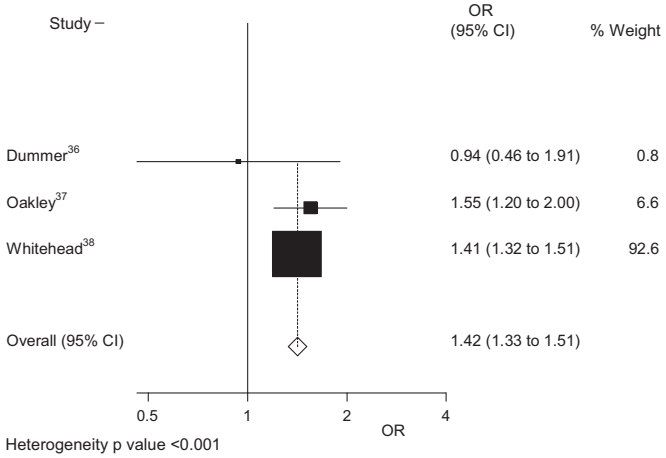


Figure 8 Neonatal mortality versus social class.

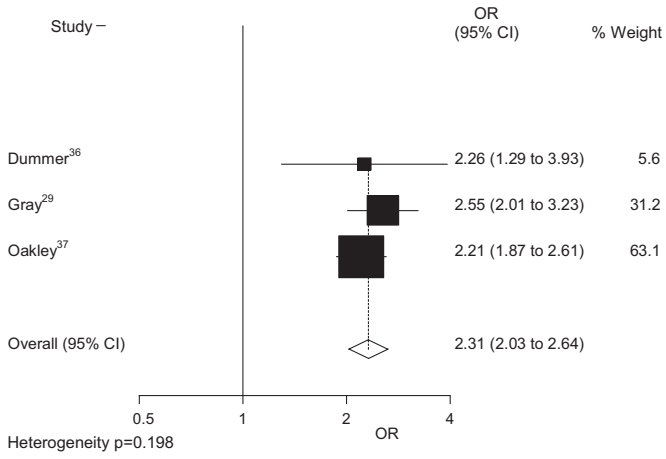


Figure 9 Postneonatal mortality versus area deprivation.

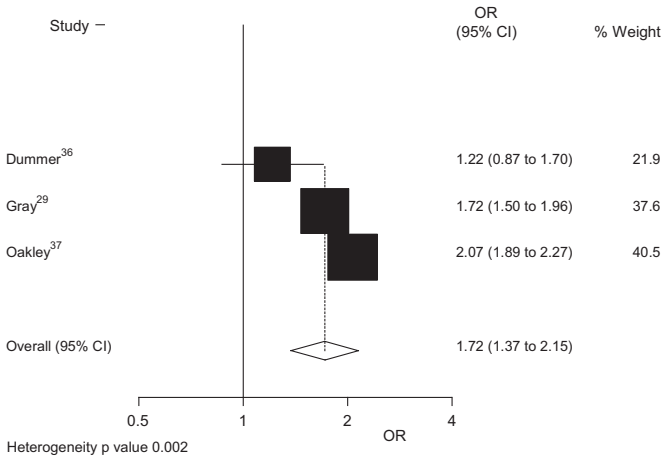


Figure 11 Overall infant mortality versus area deprivation.

classification[19] and compared Higher and Professional with Routine and manual, finding an OR of 2.63 (95% CI 1.41 to 1.91). The pooled OR was 1.69 (95% CI 1.53 to 1.87) (figure 10). Petrou *et al*[40] and Oakley *et al*[37] adjusted for a number of factors, leading to reductions in the estimated ORs as shown in online appendix 1.

Many of these studies also gave results for overall infant mortality. Combining their results, the pooled OR was 1.72 (95% CI 1.37 to 2.15) for comparing extreme quintiles of deprivation[29 36 37] (figure 11) and 1.52 (95% CI 1.44 to 1.61) for comparing the extreme social classes[36–38 40] (figure 12).

Neonatal admissions

Two studies examined associations between neonatal admissions and deprivation. Manning *et al*,[50] in a study on the Wirral in England, showed a strong linear association between deprivation, based on quartiles of Townsend scores, and the rate of neonatal admissions. The OR comparing the most and least deprived quartiles was 1.91 (95% CI 1.71 to 2.11). Jenkins *et al*[51] examined intensive care neonatal admissions in Northern Ireland, dividing wards into quintiles based on the Northern Ireland Multiple Deprivation index.[52] There was no clear pattern of the rate of admissions by quintile for the four least deprived quintiles, but the admission rate in the most deprived quintile was significantly higher than in other quintiles with an OR of 1.22 (95% CI 1.11 to 1.33) relative to the least deprived quintile. In both studies, one of the most common causes for admission was prematurity and so the strong association of prematurity with deprivation is clearly a factor.

Sudden infant death syndrome

Sudden infant death syndrome (SIDS) is a common cause of death in infancy, especially in the postneonatal period when, in spite of reducing incidence, from one recent study it accounted for about 30% of deaths in 2004–2008 (Paranjothy, 2010, unpublished). Guildea *et al*[47] found a strong association with deprivation with an OR of 3.07 (95% CI 1.97 to 4.56) comparing extreme quintiles based on the Townsend score. Sanderson *et al*[53] compared areas of poverty with those not of poverty and found an OR of 2.33 (95% CI 1.06 to 5.11); the definition of an area of poverty was not clear and so this is hard to compare with Guildea's result. Blair *et al*[54] analysed

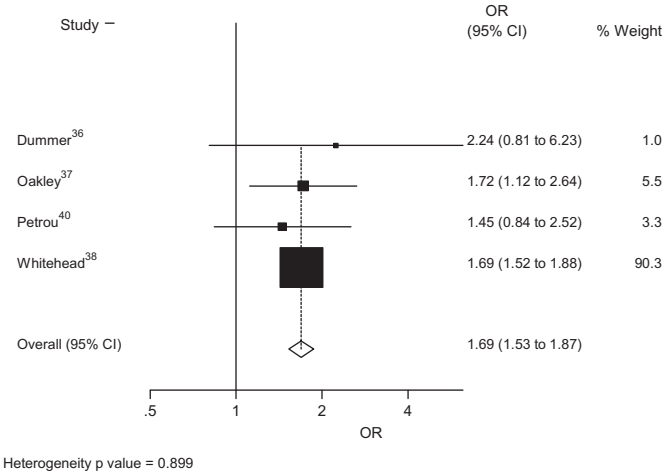


Figure 10 Postneonatal mortality versus social class.

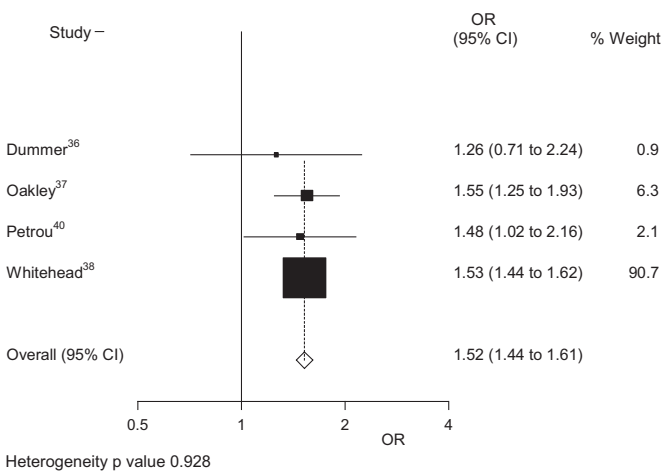


Figure 12 Overall infant mortality versus social class.

a population-based case–control study and found an OR of 18.49 (95% CI 3.62 to 94.48) for overcrowding, one aspect of deprivation. The definition used here was quite extreme, based on at least two people per room in a house, and a less extreme one may give a smaller OR. Brooke *et al*[55] also used a case–control study. Deprivation was assessed using Carstairs–Morris scores,[17] and the most deprived group had a significantly higher risk of SIDS than the remainder, even after adjustment for other factors, though the definition of the group was not clear. For social class, there was a significantly higher risk in classes IV and V than I and II in a univariate analysis; the OR remained >1 but was no longer significant in a multivariate analysis. Smith *et al*[39] looked at SIDS in the neonatal period, though the great majority occur later. Comparing the extreme quintiles, the OR was 2.20 (95% CI 1.66 to 2.91). Fleming *et al*[56] used a case–control study to examine risk factors. Comparing social classes V and I, the OR was 13.74 (95% CI 4.80 to 39.34). Using receipt of income support as a measure of individual deprivation, the OR was 4.80 (95% CI 3.68 to 6.25). Finally, Blair *et al*[57] carried out a case–control study which explored individual deprivation measures. The OR for SIDS in infants from social classes IV, V or never employed versus social classes I–III was 3.64 (95% CI 1.84 to 7.21). This became non-significant in a multivariate analysis. There is clearly great heterogeneity here, perhaps arising from different measures of deprivation, and no meta-analysis has been performed.

Overall, there appears to be some evidence for an association in keeping with the findings of an earlier worldwide systematic review, which found a link between deprivation and SIDS in 51 of 52 case–control and cohort studies.[58]

Failure to thrive

Two analyses of the same Avon Longitudinal Study of Parents and Children cohort of children were published.[59 60] Their definition of failure to thrive was based on the rate of growth, conditional on birth weight to allow for regression to the mean effects. They considered birth to 8 weeks and 8 weeks to 9 months separately and also jointly, leading to a large number of comparisons. No overall association with social class was found.

Wright *et al*[61] also used standardised rates of growth conditional on birth weight, through their thrive index, on a small birth cohort of 923 children in Gateshead, analysed by Townsend quintile. They regressed the thrive index on quintile of deprivation and reported a significant result, but the relationship appeared to be U-shaped and so interpretation is complex. An earlier study by the same group[42] on a different population did find a statistically significant result. The OR for failure to thrive at 12 months for most deprived versus intermediate area deprivation levels was 2.15 (95% CI 1.46 to 3.14). However, there was a wide variation in results at earlier ages, and those in more affluent areas had lower weight gain than in intermediate areas.

Wheeze

A single study[62] suggested a potential link between both rented housing and lower maternal education (up to and beyond GCSE stage) and wheeze in infants with ORs of 1.45 (95% CI 1.28 to 1.66) and 1.12 (95% CI 1.00 to 1.27), respectively.

Diarrhoea

A single study[62] found a significant association between diarrhoea incidence and lower maternal education (OR 1.32, 95% CI 1.19 to 1.45).

DISCUSSION

This review quantifies the evidence of inequalities in the health of infants in the UK. The socioeconomic circumstances in which an infant is conceived and born have a major effect on their early life chances and may have life course impacts.

Principal findings

The analysis demonstrates that a large number of health outcomes for UK infants are closely linked to measures of social disadvantage. There is a strong indication that the effect of social disadvantage can be measured via a range of social determinants (individual and area based) and health outcomes (eg, low birth weight, infant mortality) and found to be similar. These results are not surprising, given that prematurity, low birth weight and infant morbidity and mortality are extremely closely linked.[39 63 64] As many as two-thirds of neonatal deaths in England and Wales in 2006 were accounted for by prematurity.[65] Furthermore, some studies show that the magnitude of effect of social disadvantage on low birth weight is durable and has not markedly changed since the early 1980s.[28 31] The only infant health outcome which may not follow this pattern is failure to thrive, where there was no clear link based on evidence from the three cohorts identified.[42 60 61]

For most outcomes, the association with area deprivation was quite similar to that with social class. Social class is an individual characteristic and might be expected to have a stronger association, but it is different from the factors that are combined to give an area deprivation score. Area scores are often criticised as they are ecological measures, but the results here are quite reassuring about its use in large studies. It might be expected that when a small area was used as the basis of a deprivation score, the resulting measure would better reflect the deprivation of individuals living there than if a larger area was used. However, there was no obvious variation in its effect with the size of the areas, though these were mostly quite small. Since few studies reported an analysis in which both individual and area measures were incorporated into a single analysis, it is difficult to add to the debate about the relative importance of area and individual characteristics on health outcomes.[66]

Many of the meta-analyses showed heterogeneity so that results varied more than might be expected by

chance. Random effects models allow for this to some extent but identifying, and if possible modelling, the causes of heterogeneity is better practice. In most cases, there was insufficient detail available to do this. In the case of preterm births, the different definitions of the outcome could lead to heterogeneity. In other cases, there was variation in the comparisons of deprivation levels, as noted in low birth weight and social class. The effects of deprivation could also vary between areas in which studies were carried out and that might be another cause of heterogeneity.

Based on the results of this review, it can be strongly argued that no more epidemiological research needs to be carried out in the UK to address this general effect of area and individual measures of social deprivation on birth and infant mortality outcomes. Further research should seek to explore less researched areas such as any specific area effects and, most importantly, to explore the effect of interventions on those factors that are more proximal to maternal and infant health. This may help to throw light on the most appropriate times to provide support and the form(s) that such support should take.

Such studies could usefully build on recent research examining behavioural change interventions regarding the known intermediate determinants of infant health, for example, maternal nutrition and overweight,[67–69] and smoking.[29 67] The impact of teenage pregnancy, which is high in the UK relative to other countries, is also strongly associated with social disadvantage.[70] A recent review exploring rates of stillbirth found that maternal overweight and smoking appear to be linked to around 8000 and 2800 stillbirths annually, respectively, in the five high-income countries of Australia, Canada, the USA, the UK and the Netherlands.[67]

Another potential determinant is maternal stress. There is now clear evidence of the association of maternally reported stress,[71–73] domestic violence[74] and unintended pregnancies[73] with preterm birth or low birth weight. Although the evidence is yet to be definitive, there are a number of well-established hypothetical but evidence-based biological pathways for stressors leading to preterm birth, essentially related to hormonal, immune and vascular disfunction.[75]

Antenatal interventions carried out to date within high-income countries for socially disadvantaged women are few in number and of varying quality. In a Cochrane review, of support during pregnancy for women at risk of low birthweight babies, Hodnett *et al*[76] suggested that the women involved in the trials exhibit such a degree of deprivation that the support programmes evaluated are just not powerful enough to overcome the disadvantage experienced.

Nevertheless, there are promising approaches. Further exploration of WHO Baby Friendly Hospital Initiative (BFI) in properly evaluated and controlled settings appears to be warranted.[77] In a recent systematic review of 36 studies, the authors concluded that, while there is insufficient evidence to recommend any particular programme at the moment, some targeted antenatal care programmes are promising and warrant rigorous evaluation.[78] Harden *et al*[79] concluded that there is promise for appropriately designed early childhood interventions and youth development programmes to reduce unintended teenage pregnancy, especially if such interventions take into account the known views and emotions correlated with teenage pregnancy, such as dislike of school, low expectations of life and poor material circumstances.

Given the pervasive impact of socioeconomic conditions on almost all aspects of child health and development, unless justified to the contrary, all studies of population health, including routinely collected population data, should include robust measures of socioeconomic status and maternal and infant stress levels. Intervention outcomes should also be analysed for differential effects as well as taking into account other influences, such as a tendency to low birth weight across generations, which may be independent of economic conditions.[80]

Comparison with other studies

The findings of the review in terms of social disadvantage and low birth weight are remarkably similar to the findings of studies within the Republic of Ireland[81] and to a recent global review of reviews carried out by the Canadian Institute of Health Economics[82] which also concluded that the causes of low birth weight are multifactorial and closely inter-related. In addition, these results are very much in keeping with a recent review of worldwide studies published to 2007[83] which concluded that socioeconomic differences in low birth weight and preterm birth remain pervasive at both individual and neighbourhood levels with 93/106 studies reporting a significant association.

Conclusions and implications

It is anticipated that the results of this review will be of interest and value to policy makers and all involved directly with the care of infants and young children, as well as funders of research in this area, with two key implications emerging. First, given the clear association between child health outcomes and social disadvantage at individual and area level, governments must continue to focus on tackling social determinants, which in turn will require a cross cutting approach that includes those working in health, education, child poverty and other related policy portfolios.

Second, the absence of research on interventions through which the effects of disadvantage might be mediated is a serious shortcoming of appropriately designed interventional research.[82] Further research is urgently required to evaluate approaches to intervention, including individual behavioural studies and studies of more upstream approaches that seek to alter the material and environmental conditions before and immediately after birth. It is imperative that policy is designed and rolled-out in a manner which allows the best possible chance of a robust assessment of outcomes and costs.[84 85]

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Contributors HK, HEM and ALW carried out the literature searching and selected relevant papers. FDD, HEM, MAS and ALW completed critical appraisal, data extraction and summary of the included studies. FDD carried out statistical analyses including meta-analyses of studies where feasible. The author from the Welsh Government (CR) contributed to the conception of the study, drafted and revised sections on the policy context. He had no role in the searching, analysis or interpretation of data. Each author's contribution to the paper meets the three ICMJE guidelines for authorship. All were responsible for drafting sections of the article, revising it critically for important intellectual content and approving the final version for publication.

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Appendix 1: Studies exploring the influence of social determinants on infant health outcomes: Summary data

Studies with a prospective design are **in bold.**

Effect measures marked with an **asterisk*** have been calculated from data provided within the study to normalise the data as far as possible (to highest versus lowest deprivation quintile) and facilitate direct comparison between studies.

Social Determinant	Study	Study Design	Study Population	Sample Size & Follow Up	Response Rate	Adjustments (controlled for…)	Reported Net Effect (95% confidence interval) For high versus low social deprivation measure unless otherwise stated	Notes
Low/very low birth weight: Area deprivation								
Townsend 4th vs 1st quartile Enumeration district	↑ Bundred 2003[26]	Retrospective cohort Wirral Hospital Database	Wirral, England. 1990-2001	40,493 of 48,452 live births	83.6%	None	For low birth weight OR = 1.78 (1.56 to 2.03) For very low birth weight OR= 2.54 (1.65 to 3.90)*	
Carstairs *5th vs 1st quintile Electoral wards.*	**↑ Collingwood Bakeo 2006[27]**	**Prospective cohort** **Office for National Statistics Longitudinal Survey**	**England & Wales. 1981-1999**	**Analysis of 116,261 births grouped as 1980s and 1990s.** **1980s – 58,202 analysed from 65,666** **1990s – 58,059 analysed from 68,333**	**100%**	**Multivariate logistic analysis**	**For the 1990s:** **Unadjusted OR 1.78 (1.54 to 2.05)** **Adjusted OR 1.29 (1.12 to 1.49)***	
Index of Multiple Deprivation (component measuring household income) 5th vs 1st quintile Lower level super output areas	↑ Dibben 2006[28]	Retrospective cohort Office for National Statistics birth records	England. 1996-2000	2,894,440 births (all births) with socioeconomic data for 10%.		Multi-level modelling	Unadjusted OR for low birth weight = 2.01 (circa 1.91 to 2.12) based on the 10% sample* Unadjusted OR for very low birth weight = 1.83 (1.61 to 2.07)*	Some analyses restricted to the 10% subset, but not always clear from text.
Carstairs-Morris 5th vs 1st quintile *Postcode sector*	↑ Gray 2009[30]	Retrospective cohort Hospital records	Scotland 1994-2003	529,317 singleton live births and 2699 stillbirths delivered at 24 to 44 weeks gestation.	Records circa 99% complete 532,016 of 541,557 births = 97.7%	Multiple logistic regression	Unadjusted OR for low birth weight = 1.92 (1.85 to 2.00)*	

Social Determinant	Study	Study Design	Study Population	Sample Size & Follow Up	Response Rate	Adjustments (controlled for…)	Reported Net Effect (95% confidence interval) For high versus low social deprivation measure unless otherwise stated	Notes
Low/very low birth weight: Area deprivation cont.								
Townsend 5th vs 1st quintile Lower super output areas	↑ Paranjothy (unpublished)	Retrospective cohort National Community Child Health Database	Wales 1993-2005	407,102 live births from 408,967 births (including still births)	100%		Unadjusted OR for low birth weight = 1.80 (1.72 to 1.87) Adj for gestational age = 1.88 (1.78 to 1.98) Unadjusted OR for very low birth weight = 1.42 (1.28 to 1.56) Adj for gestational age = 0.99 (0.83 to 1.18)	
Carstairs 5th vs 1st quintile. Enumeration district.	↑ Pattenden 1999[31]	Retrospective cohort. Office for National Statistics birth records	England & Wales 1986-1992	471,411 births with coded parental occupation (random 10% sample) and birth weight	Random 10% sample with socio-economic data	Social class	For joint registrations (proxy for marital status) OR = 1.64 (1.58 to 1.70).* For single registrations OR = 1.28 (1.08 to 1.52)* For all births OR = 1.67 (1.61 to 1.73)*	
Townsend 10th versus 1st decile Enumeration district.	↑ Spencer 1999[32]	Retrospective cohort Office for National Statistics West Midlands birth records	West Midlands, England 1991-1993	194,081 from 208,567 births	93% with postcode and birth weight data = 194,081 births		OR for low birth weight =1.72 (1.63 to 1.82)* OR for very low birth weight = 1.29 (1.10 to 1.51)* Calculated for 5th versus 1st quintile for comparability with other studies	Data overlap with Pattenden 1999 and a much smaller cohort; thus excluded from meta-analysis
Townsend "affluent, intermediate, deprived" Ward level	↑ Wright 1994[33]	Retrospective cohort Newcastle Child Health Computer System	Newcastle, England June 1987- May 1988	3,653 births in all (annual cohort)	3,418 (93.6%)	None	Unadjusted relative risk most deprived vs most affluent = 2.93 (1.24 to 6.91)	Only babies born at term were considered. Data are subsumed within Collingwood (2006). Odds ratios cannot be calculated from the data given and thus, not included in the meta-analysis

Social	Study	Study Design	Study	Sample Size &	Response	Adjustments	Reported Net Effect	Notes

Determinant			Population	Follow Up	Rate	(controlled for…)	(95% confidence interval) For high versus low social deprivation measure unless otherwise stated	
Low/very low birth weight: Social class								
Unemployed vs employed mother	**↑Collingwood Bakeo 2006[27]**	**Prospective cohort** **Office for National Statistics Longitudinal Survey**	**England & Wales. 1981-1999**	**Analysis of 116,261 births grouped as 1980s and 1990s.** **1980s – 65,666** **1990s – 68,333** **Numbers analysed were 58,202 and 58,059**	**100%**	**Multivariate logistic analysis**	**For the 1990s unadjusted OR for low birth weight = 1.45 (1.27 to 1.67)** **For the 1980s unadjusted OR for low birth weight = 1.45 (1.3 to 1.7)**	
Occupational social class *V vs I*	↑Dibben 2006[28]	Retrospective cohort Office for National Statistics birth records	England. 1996-2000	2,894,440 births with social class data for 10%	Assumed to be 100%	Multi-level modelling	Adj. OR for low birth weight = 1.20 (circa 1.08 to 1.32)* Adj OR for very low birth weight = 1.39 (1.03 to 1.75) approx*	
Occupational social class *V vs I*	↑Fairley 2006[29]	Retrospective cohort Maternity discharge data and Registrar General's birth registrations	Scotland. 1980-2000	1,282, 172 births	90.3% = 1,158,139 births	Multivariate analysis	Unadj. OR for low birth weight OR 2.14 (2.04 to 2.24) for the whole 20 year period.*	OR varied with maternal age – much higher in mothers aged 35+
Occupational social class *Manual (VI/V) vs non-manual (I-III)*	↑Maher 2004[35]	Retrospective cohort All Birth registrations	England & Wales. 1983-2000	Number of births unstated	N/A	-	For low birth weight OR 1.45 (1.40 to 1.51)*	Would expect smaller effect since classes are aggregated (IV/V vs I-III)

Social Determinant	Study	Study Design	Study Population	Sample Size & Follow Up	Response Rate	Adjustments (controlled for…)	Reported Net Effect (95% confidence interval) For high versus low social deprivation measure unless otherwise stated	Notes

Low/very low birth weight: Social class cont.								
Occupational social class *V vs I*	↑Pattenden 1999[31]	Retrospective cohort Office for National Statistics birth records	England & Wales. 1986-1992	471,411 births with coded parental occupation (random 10% sample) and birth weight	Random 10% sample with social class data	Area deprivation	For joint registration, estimated OR = 1.61 (1.50 to 1.72)* An interaction between individual class and area deprivation noted. In Class V area deprivation makes little difference but in Class I it does.	Very difficult to calculate ORs from the data provided so this is an estimate. Not possible to identify data
Occupational social class *V vs I*	↑Spencer 1999[32]	Retrospective cohort Office for National Statistics West Midlands birth records	West Midlands, England 1991-1993	194,081 with ONS data from 208,567 births	10% of the sample with social class and birth weight data = 19,359 births	-	For low birth weight OR=2.17 (1.59 to 2.98)* For very low birth weight OR = 1.73 (0.68 to 4.41)*	Data overlap with Pattenden 1999 and thus excluded from meta-analysis

Low/very low birth weight: Lone parenthood								
Lone parenthood	↑Dibben 2006[28]	Retrospective cohort Office for National Statistics birth records	England. 1996-2000	2,894,440 births with socioeconomic data for 10%	Assumed to be 100%	Multi-level modelling	Modelled odds for low birth weight (non lone parent vs lone parent) OR for lone parenthood ≈ 1.16 (1.09 to 1.25)* OR for very low birth weight = 1.15 (0.99 to 1.37)*	
Lone parenthood	↑Pattenden 1999[31]	Retrospective cohort Office for National Statistics birth records	England & Wales. 1986-1992	471,411 births with coded parental occupation (random 10% sample) and birth weight	N/A	Social class and area deprivation	OR = 1.46 (1.41 to 1.52)*	

Social Determinant	Study	Study Design	Study Population	Sample Size & Follow Up	Response Rate	Adjustments (controlled for…)	Reported Net Effect (95% confidence interval) For high versus low social deprivation measure unless otherwise stated	Notes

Small for gestational age birth weight (SGA) Birth weight <10th customised centile

Occupational social class *V vs I*	↑Fairley 2006[29]	Retrospective cohort Maternity discharge data and Registrar General's birth registrations	Scotland. 1980-2000	1,282, 172 births	90.3% = 1,158,139 births	Multivariate analysis	OR = 2.49 (2.31 to 2.70) adjusted for sex and gestational age for the 20 year period.*	
Index of multiple deprivation quintiles	↑ Gardosi 2010[34]	Retrospective cohort West Midlands Perinatal Statistics database#	West Midlands, England July – December 2009	23,768 pregnancies in all	89% of cases (21,077) had complete data	Age, height, weight, parity and ethnicity, smoking and IMD quintiles	Relative risk IMD 4 vs IMD 1-3# = 1.2 (1.1 to 1.3) Relative risk IMD 5 vs IMD 1-3# = 1.2 (1.1 to 1.3)	Abstract only published to date. Both the birth weight measure and comparators differ from other studies; thus not included in a meta-analysis #Information provided by author

Preterm birth: Area deprivation								
Carstairs-Morris *5th vs 1st quintile*	↑ Gray 2008[38]	Retrospective cohort Scottish Morbidity Record	Scotland 1994-2003 [births with logistic regression data]	538,758 births	400,752/538, 758 births (86.1%)	Smoking, 'obstetric intervention', maternal age, maternal height, parity and child gender.	Odds ratio for pre-term birth= 1.27 (1.22 to 1.33) fully adjusted for smoking and other measured factors Unadjusted OR = 1.47 (1.42 to 1.52)*	Only the 1994-2003 period analysed (births with logistic regression analyses)
Townsend *5th vs 1st quintile*	↑ Paranjothy unpub.	Retrospective cohort National Community Child Health Database	Wales 1993-2005	408,102 live births, 4,719 very preterm births (22-32 weeks, 2,318 extremely pre-term (22-28 weeks)	407,102/ 408,967 (99.5%)		For birth weight <10th customised centile. Very pre-term OR = 1.44 (1.32 to 1.56)* Extremely pre-term OR = 1.38 (1.20 to 1.57)*	

Social Determinant	Study	Study Design	Study Population	Sample Size & Follow Up	Response Rate	Adjustments (controlled for…)	Reported Net Effect (95% confidence interval) For high versus low social deprivation measure unless otherwise stated	Notes
Preterm birth: Area deprivation cont.								
Child Poverty Index 10th vs 1st decile	↑Smith 2007[36]	Retrospective cohort Trent Neonatal Survey & Confidential Enquiry into Stillbirths and Infant Deaths	Former Trent Region, England 1994- 2003	7,185 very preterm (22-32 weeks) and 2655 extremely preterm (22-28 weeks) singleton births from 549,618 births	N/A	Year of birth	For comparing quintiles, for very pre-term unadjusted OR is 1.72 (1.59 to 1.86)* For extremely pre-term OR is 1.75 (1.54 to 1.98)* Calculated for 5th versus 1st quintile for comparability with other studies	Error in paper. 9,490 births in text. 7,185 in abstract - no difference arises as one figure refers to singletons only Large overlap with Smith 2009; Thus not included in meta-analysis.
UK Index of Multiple Deprivation *- quintiles*	**↑Smith 2009[37]**	**Prospective cohort.** **Former Trent region.**	**All singleton births22+0 to 32+6 weeks 1998-2007 who were alive at onset of labour**	**7,449 very preterm infants from 540,261 births.**	**Data available for 7,402/7,449 = 99%**	**Adjusted by Poisson Regression for gestation, year of birth and birth weight.**	**OR for very pre-term = 1.92 (1.78 to 2.08)* For extremely pre-term OR = 2.01 (1.77 to 2.27)***	
Townsend *"affluent, intermediate, deprived"* *Ward level*	↑ Wright 1994[33]	Retrospective cohort Newcastle Child Health Computer System	Newcastle, England June 1987- May 1988	3,653 births in all (annual cohort)	3,418 (93.6%)	None	Unadjusted relative risk for most deprived vs most affluent = 2.95 (1.61 to 5.38)	Definition of pre-term birth is assumed as <37 weeks. Odds ratios cannot be calculated from the data given and thus, not included in the meta-analysis
Preterm birth: Social class								
Occupational social class *V vs I*	↑Fairley 2006[29]	Retrospective cohort Maternity discharge data and Registrar General's birth registrations	Scotland. 1980-2000	1,282, 172 births	90.3% = 1,158,139 births	Multivariate analysis	For post 1990 data the OR for preterm birth = 1.50 (1.40 to 1.60)*.	Overlap with Gray (2008) which provides data for the more recent time period; thus not included in meta-analysis.
'Social problems' *Low income, poor housing, unsupported or single parent*	**↑ Yuan 2010[39]**	**Case-control**	**Bristol 2002-2003**	**274 preterm (23-35 weeks) and 559 control term deliveries**		Multiple logistic regression	**OR = 2.42 (1.60 to 3.66)* for preterm birth related to 'social problems'**	

Social Determinant	Study	Study Design	Study Population	Sample Size & Follow Up	Response Rate	Adjustments (controlled for…)	Reported Net Effect (95% confidence interval) For high versus low social deprivation measure unless otherwise stated	Notes
Stillbirth: Area deprivation								
Carstairs-Morris 5th vs 1st quintile *Postcode sector*	↑Gray 2009[30]	Retrospective cohort Hospital records	Scotland. 1994-2003	529,317 singleton live births and 2699 stillbirths delivered at 24 to 44 weeks gestation.	Records circa 99% complete 532,016 of 541,557 births = 97.7%	Multiple logistic regression	Unadjusted OR for stillbirth =1.56 (1,38 to 1.77) Adj. OR 1.32 (1.16 to 1.50)	
Townsend *5th vs 1st quintile* *Enumeration district*	↑Guildea 2001[42]	Retrospective cohort Child Health System Database and All Wales Perinatal Survey	Wales 1993-1998	1147 stillbirths from 211,072 births.	>98% linkage	Poisson regression	Adj. OR for stillbirth = 1.41 (1.22 to 1.62)*	Data subsumed by Paranjothy unpub.; thus not included in meta-analysis
Townsend *5th vs 1st quintile* *Lower super output area*	↑ Paranjothy unpub.	Retrospective cohort National Community Child Health Database	Wales 1993-2005	406, 654 live births, 1805 stillbirths, from 408,967 births in all	N/A		Adj. OR for stillbirth = 1.54 (1.32 to 1.80)*	
Jarman ***Low vs not low score***	**↔Smeeton 2004[43]**	**Case-control**	**SE Thames, London, England 1996-1998**	**342 stillbirths 1368 controls**	**-**	**Birth weight, Apgar score**	**Detailed results are not given but it is presumed that an association with Jarman scores is not significant.**	The number of neonatal deaths is noted as 342 in the abstract/text and 336 in Table 2

Social Determinant	Study	Study Design	Study Population	Sample Size & Follow Up	Response Rate	Adjustments (controlled for…)	Reported Net Effect (95% confidence interval) For high versus low social deprivation measure unless otherwise stated	Notes
Infant mortality: Area deprivation								
Townsend 5th vs 1st quintile *Enumeration district*	↑Bambang 2000[44]	Retrospective cohort National Confidential Enquiry into Stillbirths and Deaths in Infancy (CESDI)	West Midlands, England 1991-1993	215,651 births Recorded cause-specific perinatal deaths	209,780 from 215,651 (97.3%)	-	OR = 1.82 (1.40 to 2.37)* for antepartum events (the largest group of the causes examined) OR for all causes combined 1.91 (1.66 to 2.20)*	
Townsend 5th vs 1st quintile *Enumeration district*	↑Dummer 2005[45]	Retrospective cohort Cumbrian Birth Database	Cumbria, England 1950-1993	4889 deaths aged 0-12 months, from 283,668 live births. After 1986 the number of births is 45,166 with 489 deaths	N/A	Logistic regression	Using the most recent period (post 1986) ORs: All infant:1.20 (0.85 to 1.68)* Early neonatal 0.58 (0.34 to 0.99)* Late neo-natal 1.70 (0.67 to 4.33)* Postneonatal 2.26 (1.29 to 3.93)*	
Carstairs-Morris 5th vs 1st quintile	↑Gray 2009[30]	Retrospective cohort Hospital records	Scotland 1994-2003	529,317 singleton live births and 2699 stillbirths delivered at 24 to 44 weeks gestation.	Records circa 99% complete 529,317 of 541,557 births = 97.7%	Multiple logistic regression	ORs: Unadjusted All infant 1.72 (1.50 to 1.97) Neonatal 1.37 (1.16 to 1.62) Postneonatal 2.56 (2.02 to 3.24) Adjusted All infant 1.35 (1.17 to 1.55) Neonatal 1.19 (1.00 to 1.41) Postneonatal 1.70 (1.33 to 2.17)	

Social Determinant	Study	Study Design	Study Population	Sample Size & Follow Up	Response Rate	Adjustments (controlled for…)	Reported Net Effect (95% confidence interval) For high versus low social deprivation measure unless otherwise stated	Notes
Infant mortality: Area deprivation cont.								
Townsend *5th vs 1st quintile* *Enumeration district*	↑Guildea 2001[42]	Retrospective cohort Child Health System Database and All Wales Perinatal Survey	Wales 1993-1998	2,370 stillbirths and infant deaths from 211,072 registrable births. Age 0-12 months	>98% linkage	Age, cause of death.	ORs: Early neonatal, 1.08 (0.86 to 1.34)* Late neonatal, 1.60 (1.12 to 2.23)* Post neonatal, 2.20 (1.77 to 2.72)*	
Carstairs *5th vs 1st quintile* *Ward level*	↑Oakley 2009[48]	Retrospective cohort Birth registration, NHS Numbers for Babies (NN4B) & deprivation score from postcode given at registration.	England and Wales 2005-2006	1,315,352 singleton live births	All bar 1,387 ie 99% linked to NN4B record.	Multivariate analysis	ORs: Unadjusted All infant 2.07 (1.88 to 2.27) Neonatal 2.00 (1.79 to 2.24) Postneonatal 2.21 (1.88 to 2.61) Adjusted All infant 1.57 (1.41 to 1.75) Neonatal 1.54 (1.36 to 1.75) Postneonatal 1.62 (1.35 to 1.96)	
Jarman *Low vs not low score*	**↔Smeeton 2004[43]**	**Case-control**	**SE Thames, London, England**	**205 early neonatal deaths 820 controls**	**-**	**Birth weight, Apgar score**	**OR 0.947 (0.849 to 0.997) for early neonatal death This is stated to be the OR for a difference of one point on the Jarman scale**	The abstract stated 820 controls while Table 2 stated 818 controls
UK Index of Multiple Deprivation *2004 at super output area level* *X vs Ist decile*	↑ Smith 2010[49]	Retrospective cohort Centre for Maternal Child Enquiries (CMACE)	England 1997-2007	18,524 neonatal deaths from 6,409,691 live births	Unclear		1997-1999 OR = 2.08 (1.92 to 2.27)* 2006-2007 OR = 2.35 (2.10 to 2.63)* Calculated for 5th versus 1st quintile for comparability with other studies OR = 2.19 (2.09 to 2.29) for whole period*	CMACE has not collected data on post neonatal mortality since 1 January 2004

Social Determinant	Study	Study Design	Study Population	Sample Size & Follow Up	Response Rate	Adjustments (controlled for…)	Reported Net Effect (95% confidence interval) For high versus low social deprivation measure unless otherwise stated	Notes

Infant mortality: Social class								
Lower social class *Occupational social class* *V vs I*	↔ Dummer 2005[45]	Retrospective cohort Cumbrian Birth Database	Cumbria, England 1950-1993	4889 deaths from 283,668 live births. Age 0-12 months After 1986 the number of births is 45166 with 489 deaths	N/A	Year of birth, age at death	ORs: All infant deaths 1.29 (0.73 to 2.29)* Early neonatal 1.23 (0.53 to 2.84)* Late neonatal 0.47 (0.11 to 1.96)* Postneonatal 2.24 (0.81 to 6.23)*	
National Statistics Socio-economic Classification (NS-SEC) Higher and Professional vs Routine and manual	↑Oakley 2009[48]	Retrospective cohort Birth registration, NHS Numbers for Babies (NN4B) & deprivation score from postcode given at registration (NS-SEC).	England and Wales 2005-2006 All singleton live births.	1,315,352 singleton live births	Only 10% of the sample had both mother and father named on the birth certificate allowing coding of NS-SEC	Multivariate analysis	ORs: Unadjusted All infant 1.58 (1,27 to 1.97) Neonatal 1.54 (1.20 to 1.98) Postneonatal 1,72 (1.12 to 2.64) Adjusted All infant 1.34 (1.05 to 1.72) Neonatal 1.33 (1.00 to 1.77) Postneonatal 1.39 (0.86 to 2.24)	
Occupational social class *V vs I*	↑Petrou 2006[46]	Retrospective cohort Oxford Record Linkage Study	Oxfordshire/West Berkshire 1979-1988	117,212 births	93,657 births with social class information from 117,212 (79.9%)	Multiple logistic regression	Unadjusted ORs Early neonatal 1.60 (1.09 to 2.34)* Late neonatal 3.53 (1.71 to 7.28)* Post neonatal 1.70 (1.14 to 2.54)* Adjusted ORs Early neonatal 1.34 (0.87 to 2.04)* Late neonatal 3.61 (1.70 to 7.69)* Post neonatal 1.28 (0.84 to 1.96)*	
Occupational social class *IV-V vs I-II*	↑Whitehead 1999[47]	Retrospective cohort Office for National Statistics birth records	England & Wales 1975-1996	135,800 deaths from 14.3 million live births. Age 0-12 months	>98% linkage	-	ORs: Perinatal 1.42 (1.36 to 1.49)* Neonatal 1.41 (1.32 to 1.51)* Post neonatal 1.69 (1.52 to 1.88)* Infant: 1.53 (1.44 to 1.62)*	
Social Determinant	**Study**	**Study Design**	**Study Population**	**Sample Size & Follow Up**	**Response Rate**	**Adjustments (controlled for…)**	**Reported Net Effect (95% confidence interval) For high versus low social deprivation measure unless otherwise stated**	**Notes**

Infant mortality: Lone parenthood

Lone parenthood	↑Whitehead 1999[47]	Retrospective cohort Office for National Statistics records	England & Wales 1975-1996	135,800 deaths from 14.3 million live births.	>98% linkage	-	ORs: Perinatal 1.42 (1.36 to 1.49)* Neonatal 1.02 (0.95 to 1.11)* Postneonatal 2.06 (1.88 to 2.25)* Infant: 1.32 (1.25 to 1.41)*	

Mortality due to very preterm births								
Area deprivation *Carstairs-Morris 5th vs 1st quintile* *Postcode sector*	↑ Gray 2009[30]	Retrospective cohort Hospital records	Scotland 1994-2003	541,557 births	98.3% with deprivation		OR 1.47 (1.42 to 1.52)	Includes preterm as well as very preterm births
UK Index of Multiple Deprivation 2004 *X vs Ist decile* *Super output area*	↑ Smith 2010[49]	Retrospective cohort Centre for Maternal Child Enquiries (CMACE)	England 1997-2007	6,409,691 live births,18,524 neonatal deaths	Unclear		OR 2.40 (2.23 to 2.59)* for neonatal deaths only.	

Sudden Infant Death Syndrome (SIDS): Area deprivation								
Carstairs *Score of 7 vs score of 1*	**↑ Brooke 1997[55]**	**Case-control**	**Scotland 1992-1995**	**201 cases of SIDS (age 7 days – 12 months) and 276 controls**		**Multivariate analysis**	**Unadjusted OR: 9.59 (3.32 to 27.68)** **Adjusted OR 2.56, (1.20 to 5.49)**	
Townsend 5th vs 1st quintile Enumeration district	↑Guildea 2001[42]	Retrospective cohort Child Health System Database and All Wales Perinatal Survey	Wales. 1993-1998	165 cases of SIDS from 2366 stillbirths and infant deaths from 211,072 births. 0-12 months	>98% linkage	Age, cause of death	OR 4.42 (3.09 to 6.37)*	
Social Determinant	**Study**	**Study Design**	**Study Population**	**Sample Size & Follow Up**	**Response Rate**	**Adjustments (controlled for…)**	**Reported Net Effect** **(95% confidence interval)** **For high versus low social deprivation measure unless otherwise stated**	**Notes**

Sudden Infant Death Syndrome (SIDS): Area deprivation cont.

Area poverty *% families receiving housing benefit and/or income support*	**↑Sanderson 2002[53]**	**Case-control**	**Sheffield, England 1988-1993**	**42 cases of SIDS (7d – 12 months (32 with Edinburgh Postnatal Depression Scores) from 32,984 live births**	**N/A**	**-**	**OR 2.33 (1.06 to 5.11)**	**Some data missing. Table 1 includes information for 26 babies and 24,776 survivors only.**
UK Index of Multiple Deprivation 2004 at super output area level X vs I	↑ Smith 2010[49]	Retrospective cohort Centre for Maternal Child Enquiries (CMACE)	England 1997-2007	18,524 neonatal deaths including 543 sudden infant deaths	Unclear		1997-1999 OR = 3.62 (2.15 to 6.07) for 10 vs 1 2006-2007 OR = 2.32 (1.14 to 4.73) for 10 vs 1 Comparing quintiles the OR is 2.20 (1.66 to 2.91) for whole period*	This study examined neonatal SIDS and so isn't comparable to other SIDS studies where the majority of cases were postneonatal

Social Determinant	Study	Study Design	Study Population	Sample Size & Follow Up	Response Rate	Adjustments (controlled for…)	Reported Net Effect (95% confidence interval) For high versus low social deprivation measure unless otherwise stated	Notes
Sudden Infant Death Syndrome (SIDS): Social class								
Lower social class *Registrar General's social class IV- V vs I-III*	**Blair 2009[57]**	**Case-control**	**South West England 2003-2006**	**80 SIDS infants, 87 randomly selected controls and 82 controls at high risk of SIDS**	**N/A**	**Multivariate analysis**	**Unadjusted OR 3.64 (1.84 to 7.21)* Adjusted OR NS.**	
Lower social class *Registrar General's social class IV- V vs I-III*	**↑Brooke 1997[55]**	**Case-control**	**Scotland 1992-1995**	**201 cases of SIDS (7d – 12 months) and 276 controls**	**N/A**	**Multivariate analysis**	**Unadjusted OR 2.55 (1.66 to 3.93) Adjusted OR 1.84, (0.99 to 3.43**	
Lower social class *Registrar General's social class V vs I and IV-V vs I-II*	**↔Fleming 2003[56]**	**Case-control**	**Former health regions South West, Northern & Yorkshire England 1993-1995 and Wessex and Northern regions: 1995-1996**	**323 cases of SIDS (7d – 12 months) matched with 323 controls (from 1,338 controls)**	**89.5% cases 92.1% controls**	**Multivariate analysis**	**OR 13.74 (4.80 to 39.34) V vs I* OR 4.46 (3.00 to 6.63) IV,V vs I, II ***	***T*ext describes 325 cases. Two were not matched leaving 323 cases for analysis. Blair (1999) used the same data and estimated an odds ratio of 2.83 (2.20, 3.44) for class III-V vs I-II**

Social Determinant	Study	Study Design	Study Population	Sample Size & Follow Up	Response Rate	Adjustments (controlled for…)	Reported Net Effect (95% confidence interval) For high versus low social deprivation measure unless otherwise stated	Notes
Neonatal intensive care admission: Area deprivation								
Northern Ireland Multiple Deprivation Measure 2001 (Nobel Index) *5th vs 1st quintile* *Ward level*	↑Jenkins 2009[51]	Retrospective cohort Neonatal Intensive Care Outcomes Research & Evaluation (NICORE) database	Northern Ireland 1996-2001	4343 infants admitted from 138,444 live births	90.2% had area deprivation data.	None	OR 1.22 (1.11 to 1.33)*	J shaped relationship. Significant prematurity and Intrauterine growth restriction highest in quintile 5; Multilple birth highest in quintile 1
Townsend *4th vs 1st quartile*	↑ Manning 2005[50]	Retrospective cohort Neonatal unit records – Wirral hospital	Wirral, England 1990-2002	4,077 admissions from 47,614 live births.	N/A	-	11.1% vs 6.1% (p<0.0001). OR = 1.91 (1.74 to 2.11)*	
Townsend *5th vs 1st quintile* *Enumeration district*	↑Sundrum 2005[40]	Retrospective cohort West Sussex Computerised Child Health System	West Sussex, England 1982-1997	293 with cerebral palsy from 105,760 live births. Confirmed in childhood.	98.1% linkage	Birth weight, gestational age.	Unadjusted OR = 1.65 (1.14 to 2.59) Adjusted is 1.55 (1.06 to 2.25)	
Cerebral palsy								
Area deprivation Carstairs 5th vs 1st quintile Ward level	↑Dolk 2010[41]	Retrospective cohort. UK cerebral palsy collaborative project databases	Five regions of the UK. N. Ireland, NE England, Mersey, Oxford, Scotland 1984-1997	3,971 cases from 1 657 569 livebirths,	Diagnosis at age 5 of 3,758 from 3,971 in total (94.6%)	Birth weight	For acquired CP (post neonatal insult) OR= 1.86 (1.19 to 2.88) but heterogeneity between regions. No significant difference when restricted to normal birth weight For non-acquired CP OR= 1.16 (1.00 to 1.35)	
Lower social class *Registrar General's Social Class V vs I*	↑Sundrum 2005[40]	Retrospective cohort	West Sussex, England. 1982-1997	293 with cerebral palsy from 105,760 live births Confirmed in childhood.	81.2% linkage	Birth weight, gestational age.	Unadjusted OR 2.57 (1.27 to 5.21) Adjusted OR= 2.11 (1.04 to 4.30) For all cases of cerebral palsy	

Social Determinant	Study	Study Design	Study Population	Sample Size & Follow Up	Response Rate	Adjustments (controlled for…)	Reported Net Effect (95% confidence interval) For high versus low social deprivation measure unless otherwise stated	Notes
Growth/Failure to thrive: Area deprivation *Weight gain below the 5th centile for the general population unless otherwise stated.*								
Area deprivation *Townsend 5th vs 1st quintile*	**↔Wright 2006[61]**	**Prospective cohort** **Gateshead Millennium Baby Study**	**Gateshead, England July 1999- May 2000**	**923 infants**	**774/923 (84%)**	**Multivariate modelling**	**For sustained faltering weight OR = 0.62 (0.24 to 1.59)*** **For faltering weight (at least once during the 12 months) 0.78 (0.42 to 1.45)***	
Townsend *"affluent, intermediate, deprived"*	↑ Wright 1994[33]	Retrospective cohort Newcastle Child Health Computer System	Newcastle, England January 1987 - May1988	3,653 births in all (annual cohort)	3,418/3,653 (93.6%)	None	For infants in most deprived versus the intermediate areas the OR for failure to thrive = 2.15 (1.46 to 3.14)*.	Odds ratios cannot be calculated from the data given and thus, not included in the meta-analysis
Growth/Failure to thrive: Social class *Weight gain below the 5th centile for the general population unless otherwise stated.*								
Lower social class *Occupational social class IIm-V vs I-II*	**↔Blair 2004[59]**	**Prospective cohort** **ALSPAC**	**Avon, England. April 1991- December 1992**	**11,718 followed from 0-9 months**	**11,718/ 13,010 (90.1%)**	**Multivariate analysis**	**OR 1.21 (0.96 to 1.54)**	
Growth/Failure to thrive: Parental education *Weight gain below the 5th centile for the general population unless otherwise stated.*								
Lower parental education *less versus more than O-level*	**↔Blair 2004[59]**	**Prospective cohort** **ALSPAC**	**Avon, England. April 1991- December 1992**	**11,718 followed from 0-9 months**	**11,718/ 13,010 (90.1%)**	**Multivariate analysis**	**OR 1.15 (0.92 to 1.45)**	
Maternal education *less than GCSE versus higher education*	**↔Wright 2006[61]**	**Prospective cohort** **Gateshead Millennium Baby Study**	**Gateshead, England 1999-2000**	**774 followed from 0-12 months**	**84%**	**Multivariate modelling**	**For weight faltering (at least once during year) OR = 1.02 (0.63 to 1.64)*** **For sustained weight faltering OR = 0.56 (0.30 to 1.04)***	

Social Determinant	Study	Study Design	Study	Sample Size & Follow Up	Response Rate	Adjustments	Reported Net Effect (95% confidence interval)	Notes

Determinant			Population	Follow Up	Rate	(controlled for…)	For high versus low social deprivation measure unless otherwise stated	
Wheeze								
Maternal education *Up to O level versus higher than O level*	↑ **Baker 1998[62]**	**Prospective cohort** **ALSPAC**	**Avon, England April 1991-December 1992**	**8,501 infants followed from 0-6 months**	**80-90% Across ALSPAC**	**Multiple regression**	**Adj. OR for wheeze at 6 months =1.12 (1.00 to 1.27)***	The paper compared higher vs lower levels of education. The data are adjusted to be comparable with other studies. Table 2 says 8450 cases
Diarrhoea								
Maternal education *Up to O level versus higher than O level*	↑ **Baker 1998[62]**	**Prospective cohort** **ALSPAC**	**Avon, England April 1991-December 1992**	**8,501 infants followed from 0-6 months**	**80-90% Across ALSPAC**	**Multiple regression**	**Adj. OR for diarrhoea at 6 months = 1.32 (1.19 to 1.45)***	Table 4 says 8,488 cases

Data from prospective studies are given in **bold**. Social class always refers to occupational social class unless otherwise indicated.
Terms used: Adj Adjusted for known/likely confounders N/A Not available/not reported; NS Non significant result; OR Odds ratio

Statistical significance of the results
The author-reported statistical significance of the results is provided using an arrow convention as below.
↑ = Increasing child health outcomes with lower social status
↓ = Decreasing child health outcomes with lower social status
↔ = No significant effect or unclear

Appendix 2: List of excluded studies

Publication	Study type	Reason for exclusion
Bhattacharya S, Raja EA, Mirazo ER et al. Inherited predisposition to spontaneous preterm delivery. Obstet Gynecol 2010; 115(6): 1125-1133	Retrospective cohort	Not a study of the general population. This looks at stillbirth in a second pregnancy related to an earlier stillbirth.
Bhattacharya S, Prescott GJ, Black M et al. Recurrence risk of stillbirth in a second pregnancy. Br J Obstet Gynaecol 2010; 117: 1243-1247	Retrospective cohort	Not a study of the general population. This looks at stillbirth in a second pregnancy related to an earlier stillbirth.
Bonnellie SR. Effect of maternal age, smoking and deprivation on birthweight. Paediatr Perinat Epidemiol 2001; 15: 19-26	Retrospective cohort	Superceded by much larger and more current dataset in Gray (2009)
Harville EW, Boynton-Jarrett R, Power C et al. Childhood hardship, maternal smoking and birth outcomes. A prospective cohort study. Arch Pediatr Adolesc Med 2010; 164(6): 533-539	Prospective cohort	Links birth outcomes with maternal childhood hardship rather than social status during pregnancy,
Latif AHA, Green DA, Li WCW. The effect of deprivation on child health in Bro Taf. Public Health 1999; 113: 211-214	Retrospective cohort - data linkage	Cannot assess deprivation effect from data provided.
Maher J, Macfarlane A. Inequalities in infant mortality: trends by social class, registration status, mother's age and birthweight, England and Wales, 1976-2000. National Statistics 2004; 24: 14-22	Retrospective cohort - data linkage	Paper does not provide any useable data.
Mayhew E, Bradshaw J. Mothers, babies and the risks of	Prospective	Duplicates

poverty. Poverty 2005 ; 121 : 13-16	cohort	other publications on the Millennium Cohort Study.
Moser K, Li L, Power C. Social inequalities in low birth weight in England and Wales: trends and implications for future population health. J Epidemiol Community Health 2003; 57: 687-691	Retrospective cohort	Data subsumed by the larger dataset in Maher (2004)
Smith GCS, Shah I, White IR et al. Maternal and biochemical predictors of spontaneous preterm birth among nulliparous women: a systematic analysis in relation to the degree of prematurity. Int J Epidemiol 2006; 35: 1169-1177	Retrospective cohort – data linkage	Large degree of overlap with much larger dataset (Gray 2009)
Spencer NJ, Logan S, Gill L. Trends and social patterning of birthweight in Sheffield, 1985-94. Arch Dis Child Fetal Neonatal Ed 1999; 81: F138-F140	Retrospective cohort	Infants with median birth weight and below examined for links with social inequality – Thus not a low birth weight group & cannot extract relevant data.
Spencer N. Accounting for the social disparity in birth weight: results from an intergenerational cohort. J Epidemiol Community Health 2004; 58: 418-419	Prospective cohort	Small cohort looking at cross generational effects
Wright CM, Parker L. Forty years on: the effect of deprivation on growth in two Newcastle birth cohorts. Int J Epidemiol 2004; 33: 147-152	Prospective cohort	Paper does not provide any useable data.